



**LIFE
DINALP
BEAR**

Population level management and
conservation of brown bears in northern
Dinaric Mountains and the Alps



LIFE13 NAT/SI/000550

MONITORING OF THE EFFECTIVENESS OF MITIGATION MEASURES IN SLOVENIA

*Action D.2: Evaluation (monitoring) of the
effectiveness of mitigation measures
implemented to prevent traffic related
bear mortality*

June 2019

Title of the report: **MONITORING OF THE EFFECTIVENESS OF MITIGATION MEASURES IN SLOVENIA**

Title of the project: **LIFE DINALP BEAR (LIFE13 NAT/SI/000550): Population level management and conservation of brown bears in northern Dinaric Mountains and the Alps**

Contract no.: **Slovenia Forest Service, 152/2014
Eurofins ERICo Slovenija, P 28-09-14**

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Velenje, June 2019

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TABLE OF CONTENTS

1 INTRODUCTION	4
2 MITIGATION MEASURES IMPLEMENTED TO PREVENT TRAFFIC RELATED BEAR MORTALITY	5
2.1 DYNAMIC TRAFFIC SIGNS ALONG THE MAIN ROAD LJUBLJANA – KOČEVJE	5
2.2 INSTALATION OF ACUSTIC DETERRENTS ALONG SELECTED RAILWAY SECTIONS	6
2.3 INSTALATION OF ACUSTIC DETERRENTS ALONG SELECTED MAIN ROAD SECTIONS	8
2.4 INSTALATION OF ELECTRIC FENCE ALONG A SECTION OF LJUBLJANA - KOPER (A1) HIGHWAY	11
3 MONITORING OF THE EFFECTIVENESS OF MITIGATION MEASURES	13
3.1 MEASURING THE SPEED OF VEHICLES.....	13
3.2 MONITORING OF WILDLIFE USING CAMERA-TRAPS	14
3.3 TRAFFIC RELATED WILDLIFE MORTALITY AT SELECTED MAIN ROADS, RAILWAY SECTIONS AND HIGHWAY SECTIONS.....	17
4 CONCLUSIONS.....	19
5 REFERENCES	20

1 INTRODUCTION

Highways, roads and railways can have negative impacts on bears and many other species of wildlife. Bears killed by motor vehicles and trains are a significant part of the total documented bear mortality in Slovenia (Al Sayegh Petkovšek *et al.*, 2015a; Figure 1). Additionally, bear-vehicle collisions represent an important risk to drivers and passengers. Overall, vehicle-related mortality of bears represents a risk to long-term viability of bear population in Slovenia; moreover, highways represents barriers to bear movement and can reduce connectivity of population(s). Therefore, mitigation measures were implemented along the main road Ljubljana – Kočevje (installation of dynamic signs and acoustic deterrents) and along the railway Ljubljana – Postojna (Rakek) and Postojna - Prestranek (installation of acoustic deterrents) to reduce traffic related bear mortality in Slovenia.

With the aim to monitor the effectiveness of mitigation measures along the selected road sections of the main road Ljubljana – Kočevje and the selected railway sections between Ljubljana – Postojna (Rakek) and Postojna - Prestranek, the following activities were performed in years from 2015 to 2019: (i) monitoring of wildlife (including brown bear) in the very close vicinity of dynamics signs with the use of camera traps; (ii) measuring the speed of vehicles along the main road Ljubljana – Kočevje; and (iii) collecting data regarding traffic mortality of brown bear at selected road and railway sections, respectively.

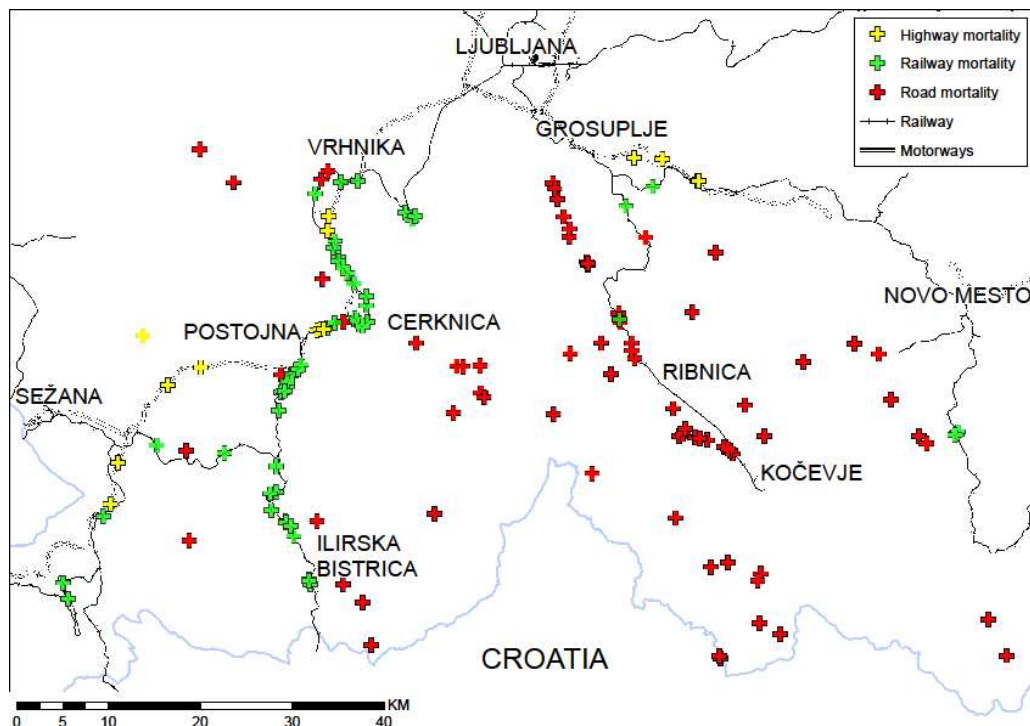


Figure 1: Map of locations of reported brown bear mortality on highways, roads and railways in Slovenia for the period 2004 – 2014 (Al Sayegh Petkovšek *et al.*, 2015a).

2 MITIGATION MEASURES IMPLEMENTED TO PREVENT TRAFFIC RELATED BEAR MORTALITY

2.1 DYNAMIC TRAFFIC SIGNS ALONG THE MAIN ROAD LJUBLJANA – KOČEVJE

At the end of the year 2015, two systems of dynamic traffic signs were placed along two sections of the main road Ljubljana – Kočevje (between Zgornje Lozine and Dolenja vas (Jasnica) and between Ortnek and Žlebič) to alert and slow down drivers in order to avoid potential collisions with wildlife, including bears. Dynamic signs were coupled to sensors capable to detect large animals approaching to the roadways. In the case of approaching bear (or ungulates), the signs light on and send the message to the driver that an animal is approaching the road. Since the sensors are not bear-specific, they provide also higher road-safety considering collisions with other large mammals, particularly ungulates.



Figure: Dynamic traffic signs Ortnek; sensors (red line), power lines (green line), solar cells (yellow rectangle) and traffic signs (triangle).



Figure: Dynamic traffic signs placed along three sections of the main road Ljubljana – Kočevje (photo: Z. Pavšek).

At the end of the year 2017, the third dynamic traffic sign was installed along another highly problematic section of the state road Ljubljana – Kočevje (south from Turjak), which was approved by the EU Commission additionally. It also helps to reduce vehicle collisions with brown bear and other wildlife by warning the drivers about approaching animal and therefore helps to reduce traffic caused bear mortality on another hot spot.



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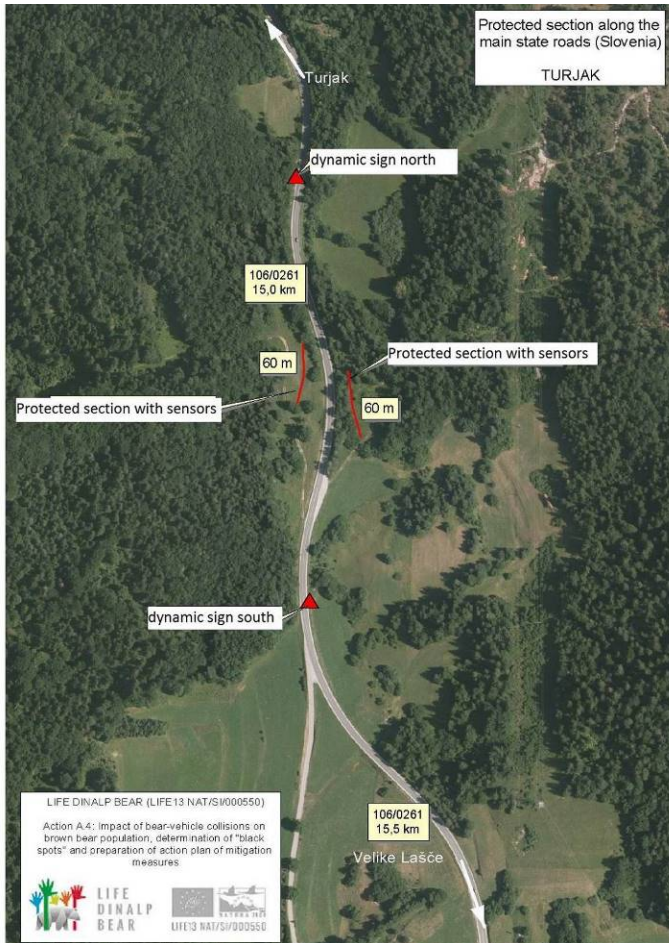


Figure: Location of three dynamic sign systems along the main road Ljubljana – Kočevje.

Figure: Dynamic traffic sign at Turjak - sensors (red line) and traffic signs (triangle).

2.2 INSTALATION OF ACUSTIC DETERRENENTS ALONG SELECTED RAILWAY SECTIONS

At the end of 2015, acoustic deterrents were installed on electric poles along the railway sections Rakek – Postojna and Postojna – Prestranek, where it was stated by field inspection that crossing of wildlife (especially brown bear) is possible.



Figure: Installation of acoustic deterrents on two types of electric poles along railway sections (photo: M. Zaluberšek).

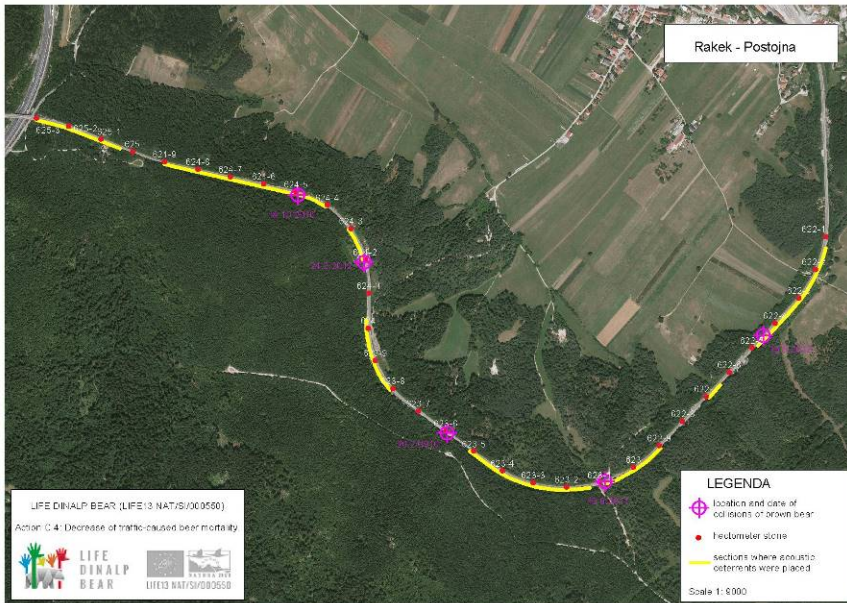


Figure: Selected section of the railway Rakek – Postojna with locations of the traffic related bear mortality, dates of collisions and sections equipped with acoustic deterrents

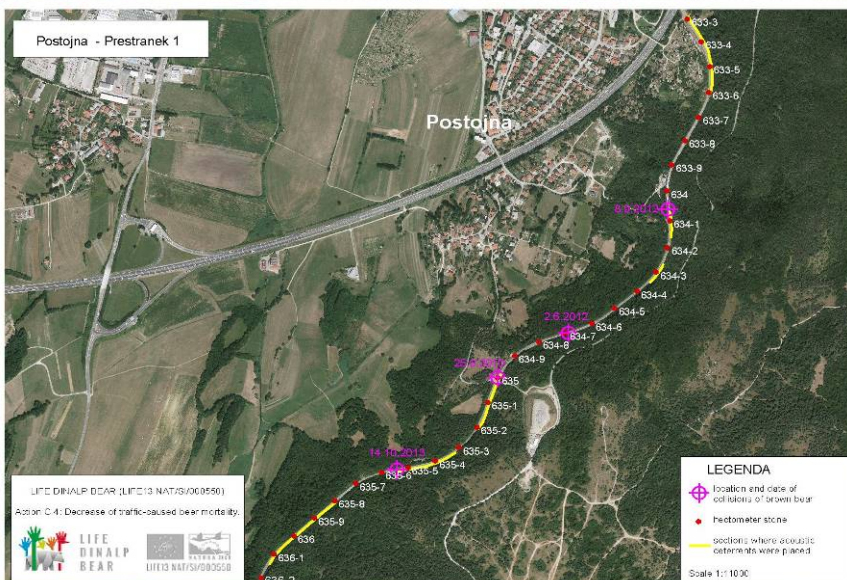


Figure: Selected section of the railway Postojna - Prestranek with locations of the traffic related bear mortality, dates of collisions and sections equipped with acoustic deterrents.

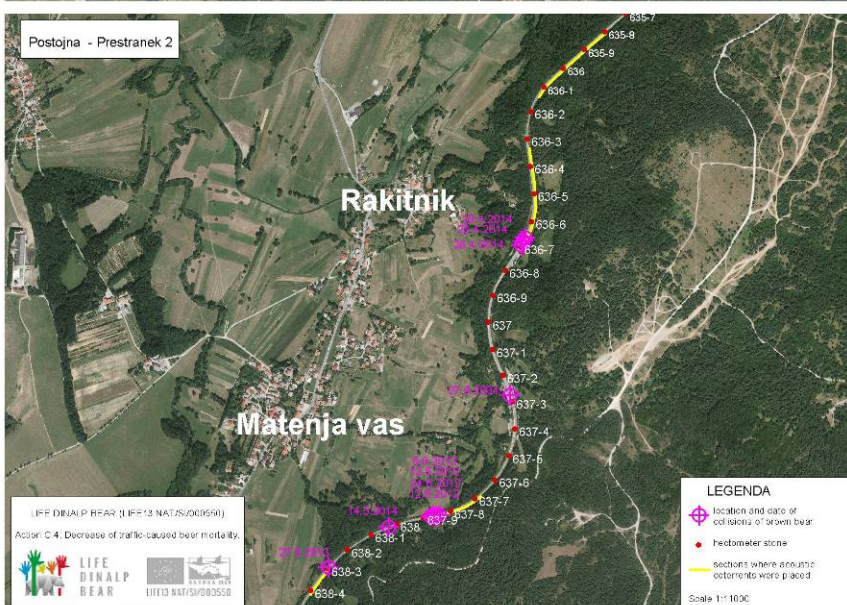


Figure: Selected section of the railway Postojna – Prestranek with locations of the traffic related bear mortality, dates of collisions and sections equipped with acoustic deterrents.

2.3 INSTALATION OF ACUSTIC DETERRENTS ALONG SELECTED MAIN ROAD SECTIONS

Acoustic deterrents (ultra- and infrasound emitting electronic devices coupled with sensors activating the sound by the approaching vehicle) were installed directly into the roadside trafficators/pillars along the 'black-spots' considering bear-vehicle collisions along the main road Ljubljana – Kočevje (Figures 13-16). In total, app. 7.5 km of roads are protected by 240 acoustic deterrents (Table 1).

Table 1: Road sections where acoustic deterrents were implemented (main road Ljubljana – Kočevje)

Number	Road	Section 1	Section 2	Length	No. of deterrents
1 Nove Ložine	106/0263	13.6	15.5	1.9 km	63
2 Gornje Ložine	106/0263	10.5	12.3	1.8 km	55
3 Ortnek	106/0262	9.1	11.5	2.4 km	73
4 Turjak	106/0261	14.2	15.6	1.3 km	49



Figure: Acoustic deterrents installed along the main road Ljubljana – Kočevje (photo: M. Zaluberšek).



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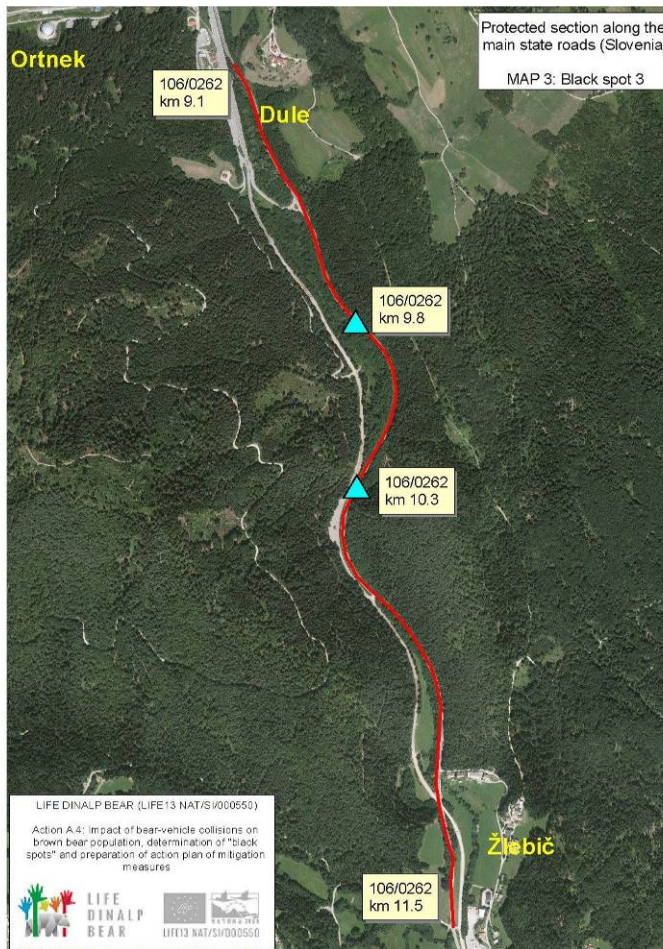


Figure 2: Selected road section along main road Ljubljana – Kočevje (between Ortnek and Žlebič), where acoustic deterrents are installed. Blue triangles represent dynamic traffic signs.

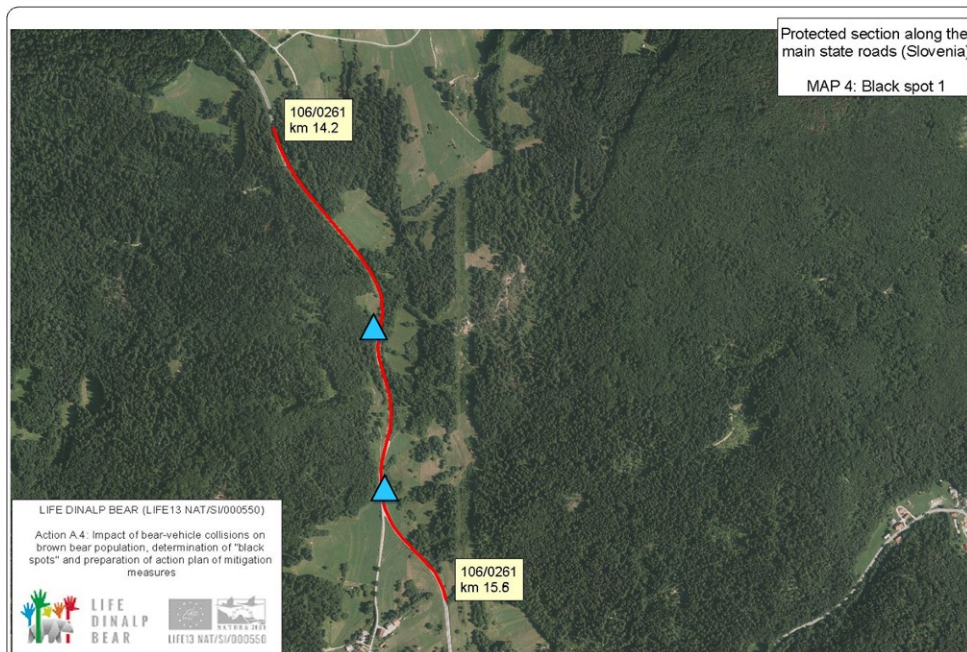


Figure: Selected road section along main road Ljubljana – Kočevje (near Rašica and Turjak), where acoustic deterrents are installed. Blue triangles represent dynamic traffic signs.

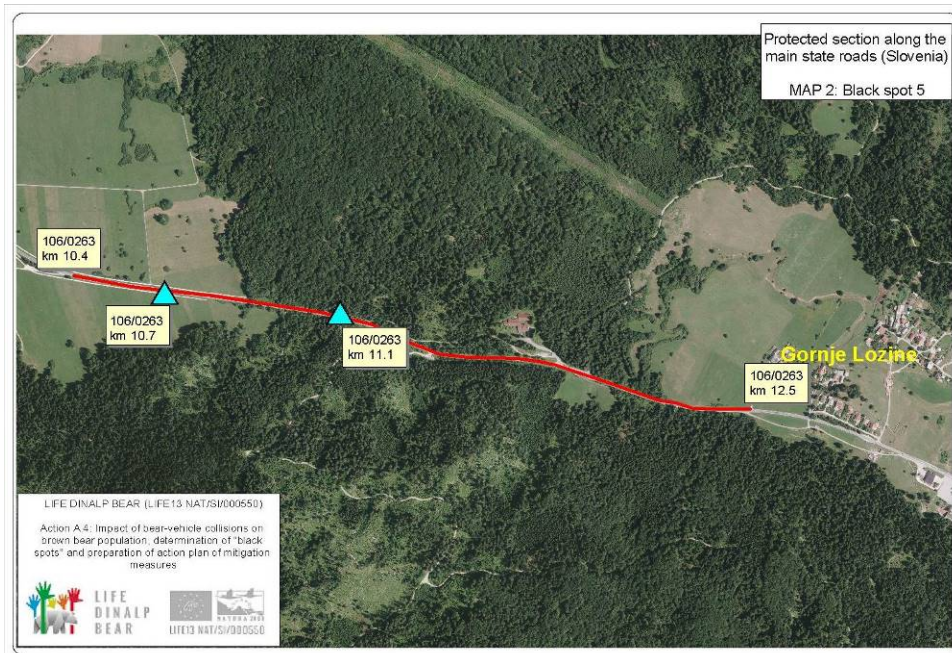


Figure: Selected road section along main road Ljubljana – Kočevje (Jasnica), where acoustic deterrents are installed. Blue triangles represent dynamic traffic signs.

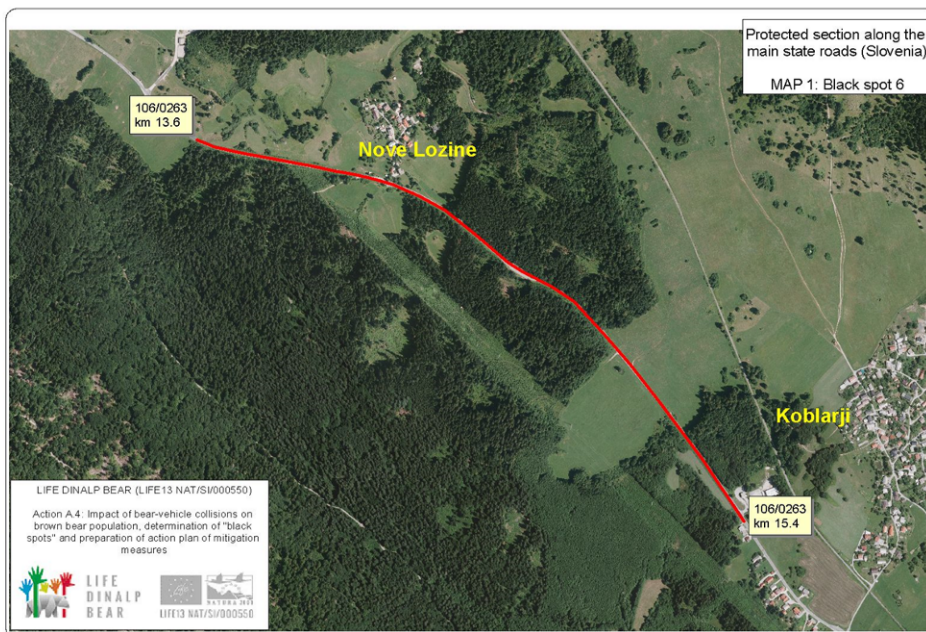


Figure: Selected road section along main road Ljubljana – Kočevje (near Nove Lozine), where acoustic deterrents are installed

2.4 INSTALATION OF ELECTRIC FENCE ALONG A SECTION OF LJUBLJANA - KOPER (A1) HIGHWAY

Reduction of brown bear-vehicle collisions on highways is an important activity in our project action “Decrease of traffic-caused bear mortality”. In Slovenia, two to three bears are killed in vehicle collisions on highways each year. Therefore, in autumn 2017 electric fence was installed in cooperation with DARS – Slovenian Motorway Company on the already existing protecting highway fence between Logatec and Ravbarkomanda to reduce vehicle collisions with brown bear and other wildlife on Ljubljana – Koper (A1) highway. An electric fence was installed along both sides of the problematic highway (A1) in total, up to 2 times 15 km (up to 30 km) of three wired (different heights) (5 km between Ravbarkomanda and Unec exit and 10 km between Unec exit and Logatec).



Figure: Electric fence installed along the Ljubljana – Koper (A1) highway (photo: S.Petkovšek, Z.Pavšek).



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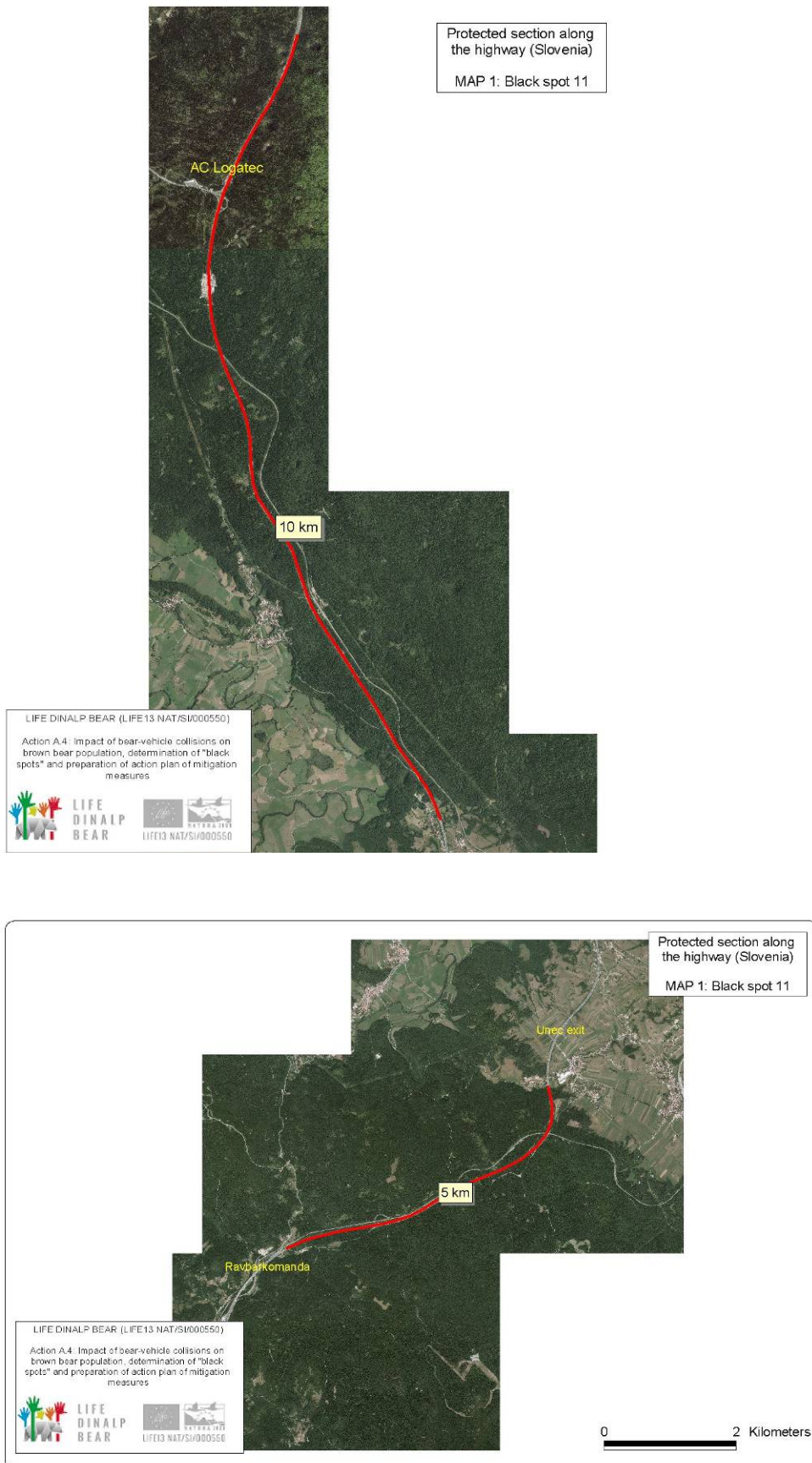


Figure: Selected highway sections along Ljubljana-Koper (A1) highway, where electric fence is installed

3 MONITORING OF THE EFFECTIVENESS OF MITIGATION MEASURES

3.1 MEASURING THE SPEED OF VEHICLES

We have measured the speed of vehicles to allow comparison of speed of different type of vehicles before installation of dynamic traffic signs and after installation. The measuring device Viacount II or traffic counter was placed on the main road Ljubljana - Kočevje between the villages Dolenja vas and Gornje Ložine (Jasnica) in November 2015 (before installation of dynamic traffic signs on this road section) (Grebenc, 2015).

Traffic counter Viacount II is radar device for counting and classification of vehicles according to the type of vehicle. Based on the Doppler method of measurement it provides accurate and reliable measurements. The device enables the counting and measurement of the speed of vehicles in both directions, e.g. incoming and outgoing traffic. Traffic counter was placed on the pole of traffic sign at a height of 2.3 m and 1.9 m away from the road. Speed limit in this section of the main road is 90 km/h.



Figure: Traffic counter placed on the pole of traffic sign near Dolenja vas (Jasnica).

Vehicles were divided into motors, cars, combined vehicles, trucks and semi-trailer. 76,603 vehicles drove past the traffic counter within two weeks. The majority of them were cars (72%); then combined vehicles were 20%, while percentages of remaining types of vehicles were significantly lower. The average speed of all vehicles was 95 km/h, and maximum speed was 226 km/h. 60% of all vehicles exceeded the speed limit (90 km/h), 31% of all vehicles have speed above 100 km/h and 6% above 120 km/h.

The average speed of vehicles of incoming traffic (to Kočevje, up the hill) was 94 km/h, and maximum speed was 216 km/h. 56.6% of all vehicles exceeded the speed limit (90 km/h).

Between years 2016-2019, we monitored the impact of the activation of dynamic signs on the speed of vehicles of incoming traffic at protected sections on the main road Ljubljana - Kočevje between the villages Dolenja vas and Gornje Ložine (Jasnica), and between Ortnek and Žlebič. In the years 2018-2019, at Turjak, we monitor the effectiveness of the new, third dynamic traffic sign system.

Traffic counter was placed on the pole with a dynamics sign. The comparison between average speed during activation and inactivation of dynamic signs was done. We determined that at all locations (Jasnica, Ortnek and Turjak) speed of vehicles, passing the active dynamic signs, was significantly lower in comparison with average speed of vehicles, passing the inactive dynamic signs. This finding was confirmed in all periods of measuring speed during inactive and active dynamics signs. The reduction of speed was for app. 8 km/h (Ortnek: 77.1 km/h vs. 69.4 km/h and Jasnica: 87.6 km/h vs. 79.4 km) and 5.5 km/h at Turjak (72.2 km/h vs. 66.6 km/h).

The reduction of speed of vehicle confirms the positive impact of activation of dynamic signs on driver's behaviour, who became more alert to the activity on the road.

3.2 MONITORING OF WILDLIFE USING CAMERA-TRAPS

Camera traps were placed at Ortnek and Jasnica before dynamic signalizations was set up in the period between November and December 2015. Monitoring of wildlife in the period of six weeks was done with the aim to record the occurrence of brown bear and other wildlife species in the area where sensors of dynamics signs were installed afterwards. The following wildlife species were observed/recorded: brown bear and roe deer at Ortnek; wild boar, red deer and roe deer at Jasnica, respectively. Brown bear was observed very close to the main road Ortnek – Žlebič. Based on this first, relatively short-lasting video surveillance in the year 2015, we concluded that the selected sections of the main road were properly selected. Therefore, the mitigation measures (implementation of dynamics signs) was expected to have positive impact on drives behaviour and will hopefully prevent traffic related mortality of large wildlife, including brown bear.

IR camera traps were placed at Ortnek and Jasnica in the direct vicinity of sensors of dynamic traffic signs in the period of five months, from March to October 2016. The following wildlife species were observed/recorded: roe deer and red fox at Ortnek; brown bear, wild boar, red deer, roe deer, red fox, European badger and European hare at Jasnica, respectively. Brown bear was observed twice very close to the main road at Jasnica. Video surveillance in the year 2016 additionally confirmed that the selected sections of the main road and locations, where dynamics signs were placed, had been properly selected. Especially at Jasnica we filmed several individuals of different wildlife species in the vicinity of road; therefore, there is significant possibility for their crossing the road and for causing vehicle collisions.



Figure: Meadow near main road at Jasnica, where camera was placed and wildlife was frequently detected (arrows indicate sensors in wooden stumps capable to detect large animals approaching the roadways) (photo: S. Al Sayegh Petkovšek).



Figure: Data collection from cameras at Ortnek (photo: S. Al Sayegh Petkovšek).



Figure: Brown bear filmed at Jasnica on 15th August 2016 and on 4th September 2016.



Figure: Red deer stags filmed on 16th July 2016 and 20th August 2016 at Jasnica.

IR camera traps were placed at Ortnek and Jasnica near sensors in the period of eight months from April to November 2017. The following wildlife species were observed/recorded at Jasnica I and Jasnica II in 2017: brown bear, wild boar, red deer, roe deer, red fox, European badger, European hare and squirrel.



Figure: Installation of IR cameras at Ortnek and sensors in wooden stumps capable to detect large animals approaching the roadway (photo: Z. Pavšek).

Again, in the year 2018, we continued to monitor the animal presence near the sensors of dynamic traffic signs. This year we focused on the third location, Turjak. The filming period lasted from March to May and from June to July. With the IR camera traps, we again managed to record large number of individuals of different wildlife species in the direct vicinity of the road section where the third dynamic traffic sign was placed. Unfortunately, they did some timberwork at the filming location. Therefore, we managed to record only few animals in the second filming period. The following wildlife species were observed/recorded at Turjak in 2018: brown bear (most likely), roe deer, wild boar, red fox, European badger, marten, European hare and squirrel



Figure: Brown bear filmed at Jasnica on 17th October 2017 and on 16th April 2019.

IR camera traps were placed at Turjak and Jasnica near sensors in the period of two months from April to June 2019. The following wildlife species were observed/recorded: brown bear, red deer, roe deer, red fox, European hare and squirrel.

Video surveillance in last five years confirmed that the selected sections of the main road and locations, where dynamics signs were placed, had been properly selected. Especially in Jasnica we filmed a high number of wildlife in the vicinity of the road.

3.3 TRAFFIC RELATED WILDLIFE MORTALITY AT SELECTED MAIN ROADS, RAILWAY SECTIONS AND HIGHWAY SECTIONS

The traffic related bear mortality at protected main road sections is presented in Table. During five years (from 2011 to 2015), before countermeasures were implemented, nine bears were road killed at relevant sections of main road Ljubljana - Kočevje which on average amounts 1,8 mortality bear cases per year. Afterwards, when acoustic deterrents were installed in 2016 and dynamic traffic signs were placed near the most problematic road sections or “hot spots” (at the end of 2015 and at the end of 2017), the bear mortality on mentioned road sections declined to 1 (one year 2) bears per year. This means that the reduction to 1,2 road mortality cases per year is so far more than 33 %. Three bears were road killed near Žlebič in 2016, 2017 and 2018, all mortality cases happened south from the dynamic traffic sign system, so not in the area of this system, which indicates to the effectiveness of the dynamic traffic signs. Two bears were road killed near Nove and Gornje Ložine (2018, 2019).

Table: Traffic related bear mortality at protected sections of main road Ljubljana – Kočevje (Al Sayegh Petkovšek *et al.* 2015, 2016, 2017; OSLIS, 2017; ZGS, 2018,2019).

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019*
Rašica -Turjak	0	1	0	1	0	0	0	0	0
Ortnek – Žlebič	0	1	0	0	0	1	1	1	0
Jasnica	1	1	0	0	1	0	0	1	0
Nove Lozine - Kobljarji	0	1	0	2	0	0	0	0	1
SUM	1	4	0	3	1	1	1	2	1

*1.1.2019-30.6.2019

In the period 2011 to 2015, before installation of acoustic deterrents, 15 mortality cases (on average 3 per year) of brown bears were registered at relevant railway sections between Ljubljana and Pivka. At the end of 2015, countermeasures were implemented, and the result was favourable, since the reduction of the bear railway mortality was more than 66 %. Before, the railway mortality was 0 to 8 bears per year (3 on average), after the implementation, the mortality was 0 to 2 animals per year (1 on average). In 2016, two bears were killed on the railway section Rakek - Postojna. At the second protected railway section Postojna - Prestranek two bear were killed in 2018 (Table).

Table: Traffic related bear mortality at protected sections of railway Rakek – Postojna and Postojna – Prestranek (Al Sayegh Petkovšek *et al.*, 2015, 2016, 2017; OSLIS, 2017; ZGS, 2018,2019).

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019*
Postojna – Prestranek	0	6	2	4	0	0	0	2	0
Rakek – Postojna	1	2	0	0	0	2	0	0	0
SUM	1	8	2	4	0	2	0	2	0

*1.1.2019-30.6.2019

The traffic related bear mortality at protected highway sections is presented in Table. During six years (from 2011 to 2016), before countermeasures were implemented, four bears were road killed at relevant sections of highway A1 Ljubljana – Koper, which on average amounts 0,7 mortality bear cases per year. Afterwards, when electric fence was installed, the bear mortality on mentioned highway sections declined to one in three years. This means that the reduction to 0,3 road mortality cases per year is so far more than 57 %. One bear was road killed on highway near Laze in 2017.

Table: Traffic related bear mortality at protected sections of highway Ljubljana – Koper (A1) (OSLIS, 2019).

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019*
Logatec - Postojna	0	0	0	4	0	0	1	0	0

*1.1.2019-30.6.2019

4 CONCLUSIONS

Based on this report of the monitoring of the effectiveness of mitigation measures done to prevent bear vehicle collision the following conclusions are made so far:

- We determined that at all locations (Jasnica, Ortnek and Turjak) speed of vehicles, passing the active dynamic signs, was significantly lower in comparison with average speed of vehicles, passing the inactive dynamic signs. This finding was confirmed in all periods of measuring speed during inactive and active dynamics signs. The reduction of speed was for app. 8 km/h (Ortnek: 77.1 km/h vs. 69.4 km/h and Jasnica: 87.6 km/h vs. 79.4 km) and 5.5 km/h at Turjak (72.2 km/h vs. 66.6 km/h). The observed reduction of speed of vehicles in years 2016-2019 confirms the positive impact of activated dynamic signs on driver's behaviour.
- IR cameras were placed at Ortnek, Jasnica and Turjak near sensors coupled with dynamic signs. The following wildlife species were recorded: brown bear, wild boar, red deer, roe deer, red fox, European badger, marten, European hare and squirrel. Brown bear was first observed in the year 2015 (before installation of dynamic signs) at Ortnek on one occasion. Then in 2016 it was observed twice very close to the main road at Jasnica. On the same location (Jasnica) it was one time again observed in 2017 and 2019. In 2018, brown bear was also observed very close to the road at Turjak. Video surveillance in last five years (2015-2019) confirmed that the selected sections of the main road and locations, where dynamics signs were placed, had been properly selected. Especially in Jasnica we filmed a high number of wildlife in the vicinity of the road.
- All together two traffic related bear mortality were recorded at protected sections of railway Rakek – Postojna in year 2016. Two casualtyts were also at protected section of railway Postojna – Prestranek in 2018. In years 2016-2018 three traffic related bear mortality were recorded at the at relevant sections of main road Ljubljana Kočevje (near Žlebič) and two bears were road killed near Nove and Gornje Ložine (2018, 2019). One bear was road killed on highway near Laze in 2017.

In the period from 2011 to 2015, before installation of acoustic deterrents and dynamic traffic signs, 9 mortality cases (1,8 per year) of brown bears were registered at relevant sections of main road Ljubljana – Kočevje, 15 mortality cases (3 per year) of brown bears at relevant railway sections between Ljubljana – Pivka and 4 mortality cases (0,7 per year) of brown bears at relevant highway sections. This means that the reduction to 1 road mortality cases per year is 33 % less and to 1 railway mortality cases and 0,3 highway cases per year is so far more than 50 %. Therefore, the effectiveness of mitigation measures at state roads, railways and highways is in accordance with our expectations. The results of the measures are even better, because the bear population in Slovenia has increased by 78%, from 560 bears in 2015 to over 1000 animals in 2019.

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